Microscopic Scattering Calculations and Data Analysis in Light Nuclei

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The Refined Resonating Group Model [1] was modified to allow for realistic NN and 3N-forces. We calculated for the ^{4}He compound-system the S-matrix using the realistic two-nucleon potential Argonne V18 and the three-nucleon Urbana IX (UIX) potential. All two fragment channels $p-^3$H, $n-^3$He, and $d-^2$H were taken into account together with approximations for the three- and four-body break-up channels. Using V18 and UIX the binding energies of the fragments and the thresholds were reproduced within 20 keV or better. For the scattering calculation we include all S, P and D wave contributions to the $J^\pi = 0^+, 1^+, 2^+, 0^-, 1^-$ and 2^- channels. For the V18 alone we allow also for F waves leading to $2^-, 3^-$, and 4^- channels. The results are compared either directly to data or, on a partial-wave by partial-wave basis, to a comprehensive R-matrix analysis of a large amount of data in the ^{4}He system.

The overall agreement between data and the calculated parameter-free results is quite good. For the V18 alone, the agreement in most cases is much better than in a previous calculation [2] employing a version of the Bonn potential. The partial-wave comparison with the R-matrix analysis yields in many cases perfect quantitative agreement, but also clear-cut differences. On one side these deviations between calculation and data could be used to improve the three-nucleon force. On the other side inconsistencies in the database and regions sensitive to nuclear parameters call for additional or improved data.

Restricting the Gaussian width parameters of the scattering calculation to those independent within the channel-radius of an R-matrix analysis, the R-matrix poles and partial width amplitudes can be calculated and compared directly. We find the properties of the low-lying poles rather insensitive to parameter variations. The channel radii determine an energy region from which on R-matrix poles are abundant and highly dependent on small parameter modifications.

Due to computer-time limitations nuclei above mass number 4 are at the moment not accessible to realistic NN and 3N-forces. For heavier systems only semi-realistic forces are feasible. These forces do no more allow to reproduce the many thresholds by unrestricted variation. Hence, in a scattering calculation artifacts due to this failure cannot be excluded. For the direct determination of R-matrix poles non-orthogonal wave functions, reproducing the various thresholds very well, can be used avoiding these artifacts. First applications of the above treatment to the ^{7}Li and ^{11}B systems are discussed.

1. H.M.Hofmann, in Lecture Notes in Physics 273 (Springer,Heidelberg,1987)

2. H.M.Hofmann and G.M. Hale, Nucl. Phys. **A613**, 69 (1997).

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